Fate, Transport, and Interactions of Metals

Michael P. Dieter

National Institute of Environmental Health Sciences, Research Triangle Park, NC 27709 USA

A joint United States–Mexico conference, "Fate, Transport, and Interactions of Metals" was held in Tuscon, Arizona, USA, 13–16 April 1993. The conference was hosted by the University of Arizona Center for Toxicology and co-sponsored by the NIEHS Superfund Basic Research Program, the National University of Mexico Program for the Environment, and the Pan American Health Organization. The purpose of the conference was to promote an exchange of scientific information on potentially toxic metals that may be present in hazardous waste sites. By sharing this technology, the United States and Mexico are better able to define the extent of contamination, evaluate and improve risk estimates for human health, intervene when populations are adversely affected, and prevent or reduce the incidence of pollution in the future.

More than 150 teachers, students, policymakers, and scientists from Mexico and the United States attended the 3-day conference, with major addresses by Octavio Rivero Serrano, president of the National University of Mexico Program for the Environment, and Kenneth Olden, director of NIEHS. Simultaneous translations in Spanish and English contributed to the international atmosphere of the meeting.

In opening the meeting, William Suk stated that the Superfund Research Program funded by NIEHS started at $3 million in 1987 and is currently funded at $32 million, representing 1.3% of the total federal Superfund budget for basic research.

Serrano explained that there are 17 agencies connected with the environment in Mexico. Expanding technologies associated with foundries, precious metal extraction, and chemical processes generate toxic wastes, with an environmental release of up to 14,000 tons of metals per year. It is expensive to reduce hazardous risks from metals, costing up to $200 per ton. Mexico would prefer to reduce the risk from hazardous wastes with improved technologies. Serrano described educational programs for university professors not directly involved with environmental health, such as engineers and architects, to encourage the development of technology for waste removal, waste remediation, and incorporation of waste reduction processes coincidental with industrial expansion.

Olden stated that studies on metal toxicology were consistent with the role of NIEHS in protecting human health. The institute is already sponsoring extensive studies on the mechanisms of lead toxicity in the United States, epidemiological studies are ongoing in Canada and Australia, and intervention efforts using succimer, a new chelator for metals, will be part of upcoming clinical trials to determine the effectiveness of this compound for reducing the toxic burden in lead-exposed children. Major emphasis for Superfund research dollars at NIEHS will be directed at environmental equity, especially for children, ecology studies including biodiversity, bioavailability, and bioaccumulation research, transfer of technology to include strategies for risk assessment and remediation, and prevention research, especially in development of improved disposal processes for combustion energy, as half of the hazardous wastes in the United States are incinerated. Olden emphasized that environmental health and human health are closely allied and that, although technological progress improves lifestyles, pollution often is an unwelcome side effect. Such side effects are no longer acceptable. International cooperation is required to find a remedy for global pollution.

Metal contaminants that are present in the environment are mobile and are easily transported in the atmosphere and by water irrespective of geographic features. Some examples of this in the United States and Mexico were presented in six different morning and afternoon sessions, including studies of trace metal distribution in lagoons around the Gulf of Mexico, arsenic movements in watersheds north of Boston, chromium transfer from tannery industries via settling ponds to aquifers and wells in the Leon Valley, migration of volatile organic contaminants at the Nogales border, and soil and airborne dust contamination of chromium in condominiums built on hazardous waste sites in Jersey City.

Waste disposal of metal products are particularly difficult because they are not metabolized and can only be transferred from one location to another. Thomas Clarkson, of the University of Rochester, related the history of metal pollution through the centuries and pointed out examples such as the spike in lead contamination that coincided with the development of transportation and the use of leaded gasoline. Outbreaks of poisoning by lead, mercury, arsenic, cadmium, manganese, cobalt, beryllium, and nickel in the United States, Scandanavian countries, and the Far East serve as reminders that metal products remain *in situ* and, when disturbed, emerge to affect toxicity via airborne transport and inhalation, direct ingestion in the water or the diet, or after biomagnification in the food chain.

Presentations at the conference ranged from the importance of metal speciation and oxidation–reduction reactions and plasma-source mass spectrometry techniques to complex interactions between mixtures of metals and humic acids at hazardous waste sites and bioremediation processes. Ismael Herrera Revilla presented an overview of remediation processes, citing earlier *in situ* processes to excavate the soil to remove contaminants. Such processes were stopped in the mid-1980s because they were expensive and only relocated the problem. Newer *in situ* treatment uses complexation of metals with natural or commercial ligands to improve the conditions for biodegradation or non-*in situ* methods such as pumping and treatment of water and incorporation of wastes into commercial products like asphalt. Julio Landgrave described this type of bioremediation process being developed in Leon in an effort to maintain the tannery industries and still reduce the level of pollution. A pilot plant was designed to reduce chromium contamination in the environment; chromium was extracted from the effluent so that 60% of the water could be safely recycled and the chromium returned to the plant for reutilization. The process was reasonable in cost, indicating that larger scale development might be practical.

The conference did not ignore the problems that are posed by complex mixtures of toxic metals in hazardous waste sites. An entire session was devoted to laboratory experiments with animals and cell cultures showing that mixtures of specific heavy metals yield toxic responses that can be additive, synergistic, or even antagonistic. As yet there are no clear answers to the human risks or environmental hazards posed by mixtures of multiple chemicals in hazardous waste sites, mainly because their

Address correspondence to M. Dieter, NIEHS, MD WC-01, PO Box 12233, Research Triangle Park, NC 27709 USA.

chemical compositions are unlimited and largely unknown.

A session on public policy responses reemphasized that contamination of ecosystems in the environment are inextricably connected with human hazards and that local monitoring using biomarkers or sentinel species are paramount to protecting public health. There are obvious needs for further and more comprehensive studies of multiple exposures and repeated exposures of human populations residing near specific hazardous waste sites. Those most at risk were described as people with less developed environmental awareness, those with lower incomes and therefore little political influence, and often as minorities already residing close to sources of toxic wastes or with hazardous waste sites in their neighborhoods. It was suggested that additional funds be provided to establish adequate prevention programs so that remediation programs can be reduced or eliminated.